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DOCUMENTATION FOR THE SHIP HYDROSTATICS COMPUTER PROGRAM HYDRO.(U)
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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084

DOCUMENTATION FOR THE SHIP HYDROSTATICS COMPUTER PROGRAM HYDRO

BY

STEVEN C. FISHER

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SHIP PERFORMANCE DEPARTMENT REPORT

OCTOBER 1980 DTNSRDC/SPD-0965-01

DOCUMENTATION FOR THE SHIP HYDROSTATICS COMPUTER PROGRAM HYDRO

NDW-DTNSRDC 5602/30 (2-80)
(supersedes 3960/46)

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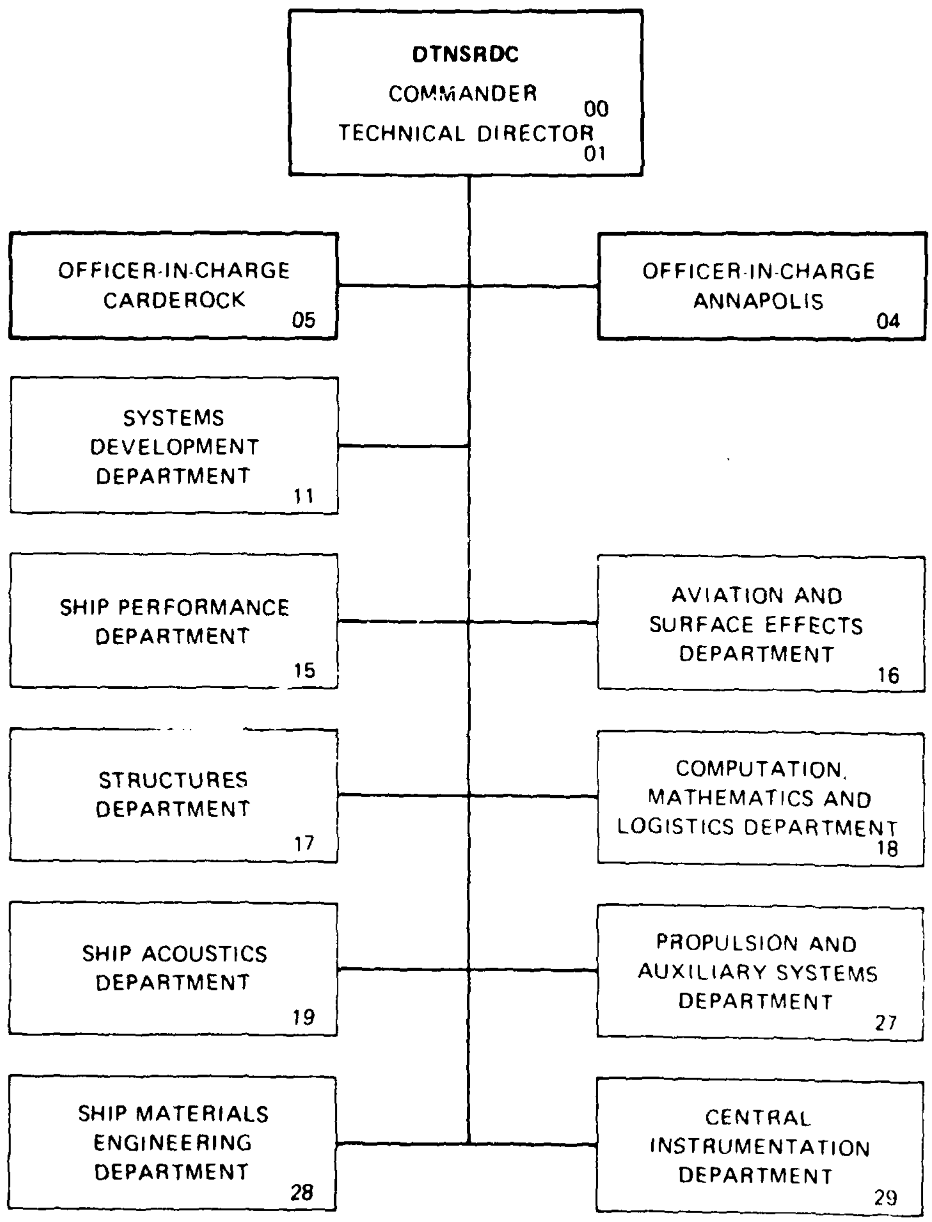

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The computer program HYDRO, a hydrostatics program using cubic parametric splines for curve fitting, is presented. Program documentation and the instructions on program usage are included.

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NOMENCLATURE

SYMBOL	CC SYMBOL		DESCRIPTION
A	A		Sectional area
A_M	AM		Midships sectional area
A_{WA}	AWA		Waterplane area of afterbody
A_{WF}	AWF		Waterplane area of forebody
A_{WT}	AWT		Waterplane area
A_X	AX		Maximum transverse Sectional area
B	B		Beam
Ⓑ	CIRCB	$B_M/\nabla_T^{1/3}$	R.E. Froude's breadth coefficient
B_M	BM		Beam at amidships
B_X	BX		Beam, measured on the waterline at the maximum area section
C_B	CB	$\nabla_T/(L_{WL}\ B_X\ T_X)$	Block coefficient
C_M	CM	$A_M/(B_M\ T_M)$	Midship section coefficient
C_P	CP	$\nabla_T/(L_{WL}\ A_X)$	Longitudinal prismatic coefficient
C_{PA}	CPA	$\nabla_A/(L_A\ A_M)$	Longitudinal prismatic coefficient of afterbody
C_{PE}	CPE	$\nabla_E/(L_E\ A_X)$	Longitudinal prismatic coefficient of entrance
C_{PF}	CPF	$\nabla_F/(L_F\ A_M)$	Longitudinal prismatic coefficient of forebody
C_{PR}	CPR	$\nabla_R/(L_R\ A_X)$	Longitudinal prismatic coefficient of run
C_S	CS	$S/(\nabla_T\ L_{WL})^{1/2}$	Wetted surface coefficient in non-dimensional form
C_{VP}	CVP	$\nabla_T/(A_{WT}\ T_X)$	Vertical prismatic coefficient
C_{VPA}	CVPA	$\nabla_A/(A_{WA}\ T_{MA})$	Vertical prismatic coefficient of afterbody

SYMBOL	CC SYMBOL		DESCRIPTION
C_{VPF}	CVPF	$\nabla_F/(A_{WF}\ T_{MF})$	Vertical prismatic coefficient of forebody
C_{WP}	CWP	$A_{WT}/(L_{WL}\ B_X)$	Waterplane coefficient
C_{WPA}	CWPA	$A_{WA}/(L_A\ B_M)$	Waterplane coefficient of afterbody
C_{WPF}	CWPF	$A_{WF}/(L_F\ B_M)$	Waterplane coefficient of forebody
C_{WS}	CWS	$S/(\Delta_T\ L_{WL})^{1/2}$	Taylors wetted surface coefficient in dimensional form
C_X	CX	$A_X/(B_X\ T_X)$	Maximum transverse section coefficient
C_∇	CVOL	∇_T/L_{WL}^3	Volumetric coefficient
D-L	D-L	$\Delta_T/(0.01L)^3$	Displacement - length ratio
f_E	FTE		Taylor's "f" at forward perpendicular
$\overline{FB}$	XFB		Longitudinal center of bouyancy from F.P. or forward end of WL (formerly LCB)
$\overline{FF}$	XFF		Distance of center of flotation from F.P. or forward end of WL (formerly LCF)
K	CIRCK	$0.5833\frac{V}{\Delta_T^{1/6}}$	R.E. Froude's speed-displacement coefficient, ratio of ship speed of a wave having its length proportional to cube root of volume of displacement for design condition of ship.
L	L		Length, in general
L_E	LE		Length of entrance, from FP to forward end of parallel middlebody or maximum section
L_P	LP		Length of parallel middlebody
L_{PP}	LPP		Length between perpendiculars

SYMBOL	CC SYMBOL		DESCRIPTION
L_R	LR		Length of run, from section of maximum area or after end of parallel middle-body to waterline termination or other designated point
L_{WL}	LWL		Length on waterline
M	CIRCM	$L_{PP}/\nabla^{1/3}$	R.E. Froudes' length coefficient or length-displacement ratio
P	CIRCP	$0.746 \frac{V}{(L_{WL} C_P)^{1/2}}$	Baker's speed constant on basis of which ships of equal wave-making length can be compared.
T_M	TM		Draft at amidships
T_{MA}	TMA		Draft of afterbody at 0.75 L
T_{MF}	TMF		Draft of forebody at 0.25 L
S	S		Wetted Surface
S	CIRCS	$S/\nabla^{2/3}$	R.E. Froudes' wetted surface coefficient
t_E	TTE		Taylor tangent to area curve- intercept of tangent to curve at the bow on the midship ordinate, expressed as a ratio of the midship ordinate
T	CIRCT	$T_M/\nabla^{1/3}$	R.E. Froudes' draft coefficient
T_X	TX		Draft at maximum area section
ΔT	DIS		Displacement of the ship in tons of 2240 lbs usually given for the design condition in salt water at 59°. Conversion from model displacement in fresh water involves ratio of densities of salt and and fresh water. The displacement volume of the model is converted to displacement using 35.970 cu ft/ton and the displacement volume for the ship is converted to displacement using 34.977 cu. ft/ton. (continued on next page)

GLOSSARY (Continued)

SYMBOL	CC SYMBOL	DESCRIPTION
ΔT (cont)	DIS	The ratio of the displacement, model to ship, used is $(35.970/34.977)^3 = (1.0284)^3$. Standard usage in NSRDC is for a model temperature of 68°F or 20°C and latitude of Washington D.C., and a ship temperature of 59°F or 15°C, 3.5 percent salinity, 45° north latitude.
V	V	Speed of ship, knots
∇_A		Volume of afterbody
∇_E		Volume of entrance
∇_F		Volume of forebody
∇_R		Volume of run
∇_T		Total volume

ENGLISH/SI EQUIVALENTS

1 degree (angle)	= 0.01745 rad (radians)
1 foot	= 0.3048 m (meters)
1 foot per second	= 0.3048 m/sec (meters per second)
1 inch	= 25.40 mm (millimeters)
1 knot	= 0.5144 m/s (meters per second)
1 lb (force)	= 4.448 N (Newtons)
1 lb (force) - inch	= 0.1130 N·m (Newton-meter)
1 long ton (2240 lb)	= 1.016 metric tons, or 1016 kilograms
1 horsepower	= 0.746 kW (kilowatts)

ABSTRACT

The computer program HYDRO, a hydrostatics program using cubic parametric splines for curve fitting, is presented. Program documentation and the instructions on program usage are included.

ADMINISTRATIVE INFORMATION

This Project was authorized and funded by the Naval Material Command (NAVMAT) Ship Performance and Hydromechanics Program under Program Element 62543N, Subproject Number 43-421-001, Work Unit Number 1500-104-32.

INTRODUCTION

Previously at DTNSRDC, a complete hydrostatic analysis of a given hull form required the execution of three separate computer programs. In an effort to consolidate and improve these programs, a new computer program, HYDRO, was written. Because the number of programs has been reduced to one, the time required to complete the analysis has been shortened. The original programs used the trapazoidal rule for calculating the sectional areas and volumes. HYDRO uses parametric splines to define the hull shape to allow exact integration, which improves the accuracy of the results.

Program documentation is included below. Instructions on program usage and a sample output are also given.

OVERVIEW OF THE PROGRAM HYDRO

The computer program HYDRO defines the stations and curves using a cubic parametric spline to fit the offsets. Each pair of parametric splines (x(t), y (t)) define a segment between two consecutive points. The equations are:

$$x = a_x t^3 + b_x t^2 + c_x t + d_x$$

$$y = a_y t^3 + b_y t^2 + c_y t + d_y$$

$$0 \le t \le 1$$

The sectional areas are obtained by integrating the splines. The volume, waterplane area, and wetted surface are obtained by integrating parametric splines that are fitted to the sectional area, waterplane, and wetted surface curves. However, the station girths cannot be found through integration of the splines. The girths are calculated by taking evenly spaced points that are interpolated between the original offsets, and integrated using Simpson's rule.

The endpoints of the sectional area, waterplane, and wetted surface curves are at the furthest forward and furthest aft stations with non-zero sectional area, if no bow or stern profile has been entered. If the bow or stern profile has been included, the endpoints are taken at the intersection of the waterline with the bow or stern. If the bow has a bulb, the tip of the bulb is used as the forward endpoint instead of the bow waterline intersection.

HYDRO consists of 12 subprograms, and uses 4 common blocks. A block diagram of the program HYDRO is shown in Figure 1, and a brief description of each subprogram and common block is given in Appendix A. The core requirement for loading and running the program is approximately 65,000 octal words. The amount of time required to run the program depends upon the number of stations, points per station, and drafts, but normally does not exceed 20 seconds.

INPUT INFORMATION

Table 1 contains a list of the required input information and the respective format needed to run the program. An example input deck is shown in Table 2 , and the corresponding input values are shown in Table 3.

The offsets of the model can either be input in the form required by the earlier hydrostatics programs, (IPROG = 0) or in the form used by the NAVSEA lines generation programs and the TEKTRONICS computer program DIGITIZE (IPROG = 1). The stations must be in order, from the bow to the stern, and the offsets for each station must be in order of increasing waterline height. A maximum of 40 stations and 40 points per station are allowed. The coordinate system for the model offsets is shown in Figure 2.

Taylors' f and t, and the half angle of entrance can either be input or calculated, depending on the value of the variable ICALC. The calculated values may not be accurate if the bow sections have an unusual shape.

HYDRO allows additional sectional area and wetted surface to be input. This feature adjusts the results to reflect the additional volume and wetted surface due to items that might not be indicated by the station offsets, such as skeg. The additional volume is added indirectly by increasing the sectional area of certain stations, so that the LCB will be shifted accordingly.

Up to six drafts can be used. The drafts are input at the bow and the stern so the model can be trimmed. The drafts are given at distances from the waterline to the baseline.

OUTPUT INFORMATION

The output, shown in Table 4, is given in English and SI units (MET = 1). The output tables are taken directly from the earlier hydrostatics programs. It should be noted that the L_{WL} coefficients are calculated using the waterline length input into the program. The program output consists of an echo of station offsets, control variables, station areas and girths, tables of hull coefficients, and non-dimensionalized beams and section areas. The printing of the station offsets is supressed if the value of the variable INSTAT is greater than zero.

The output tables are given in English, SI, and English and SI units, depending upon the value of the variable MET. Table 4 shows the output tables in English and SI units (MET = 1). Tables 5 and 6 show the output tables in English (MET = 0) and in SI (MET = 2) units.

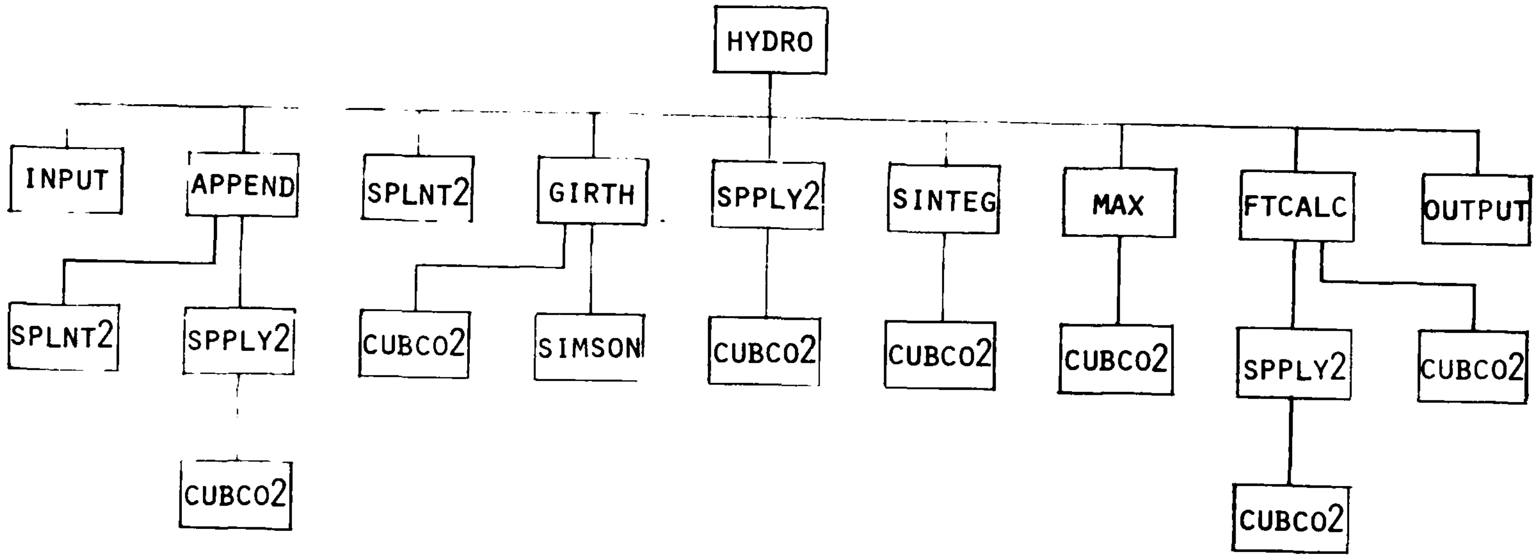

Figure 1 - Block Diagram of the Program HYDRO

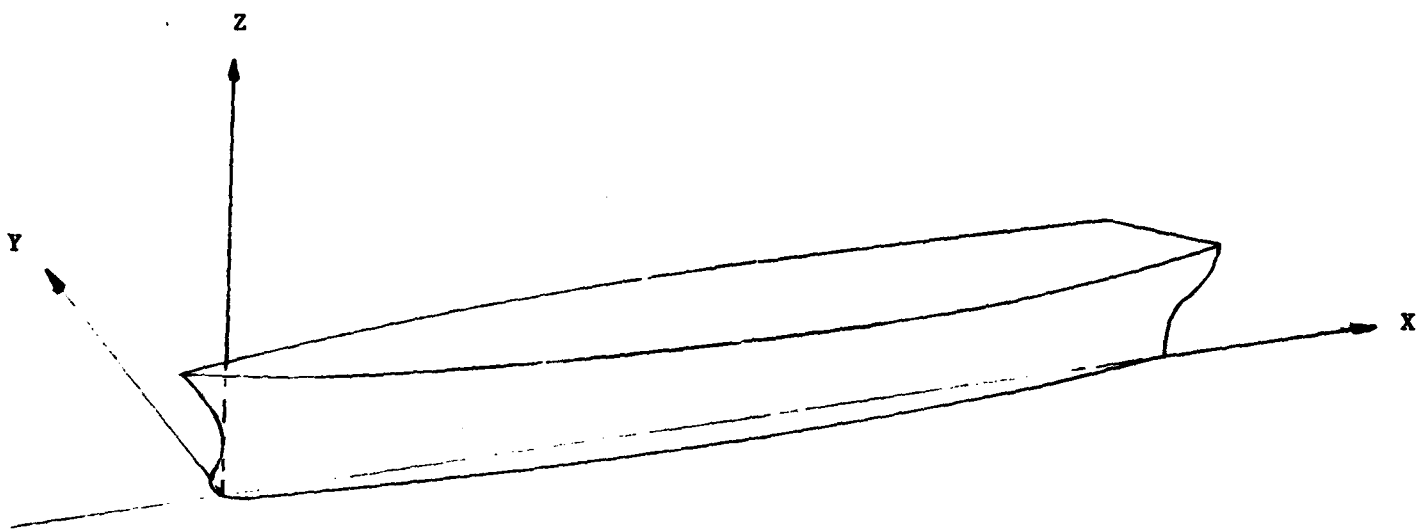

FIGURE 2 - HULL OFFSET COORDINATE SYSTEM

TABLE 1

Required Input Information for Running HYDRO

CARD	FORMAT	COL	NAME	DESCRIPTION
1	A10	1-10	MODEL	Model number
2	8A10	1-80	TITLE	The title for the output
3	F10.5	1-10	XLAM	Ship to model scale
	F10.5	11-20	V	Model speed (knots)
	F10.5	21-30	XLWL	L_{WL}, ft (model)
	F10.5	31-40	XLPP	L_{PP}, ft (model)
	F10.5	41-50	SS	Station spacing ft (model)
4	F10.5	1-10	XX	X axis scaling factor
	F10.5	11-20	YY	Y axis scaling factor
	F10.5	21-30	ZZ	Z axis scaling factor
	F10.5	31-40	XBS	X axis scaling factor for bow and stern profiles
	F10.5	41-50	YBS	Z axis scaling factor for bow and stern profiles
5	F10.5	1-10	XM	Distance from bow to amidships, ft (model)
	F10.5	11-20	WATDEN	Water density, lbs/ft^3 (usually 62.4)
	I5	21-25	MET	Output Index MET=0 English Units MET=1 English and Metric units MET=2 Metric Units
	I5	26-30	ISTAT	Print control for station offsets. If ISTAT > 0, suppress printing

Table 1 - Required Input Information for Running HYDRO (Cont)

CARD	FORMAT	COL	NAME	DESCRIPTION
6	F10.5	1-10	XLP	Length of parallel middlebody
	F10.5	11-20	ENTA	Half angle of entrance, degrees
	F10.5	21-30	FTE	Taylors' f
	F10.5	31-40	TTE	Taylors' t
	I5	41-45	ICALC	If not zero, ENTA, FTE, & TTE will be calculated
7	I5	1-5	N	Number of stations
	I5	6-10	NDRAFT	Number of drafts
	I5	11-15	IPROG	=0 if offsets are in the old format =1 if offsets are in the new format
	I5	16-20	IBOW	=0 if no bow or stern profile is entered =1 if only a bow profile is entered =2 if only a stern profile is entered =3 if both a bow and a stern profile are entered
8	I5	1-5	NSTAT	Number of stations that have extra sectional area that are not indicated by the offsets
	F10.5	6-15	EXWET	Additional wetted surface not indicated by the offsets
8a	F10.5	1-10	XXL	Station number with extra sectional area
	F10.5	11-20	EXVOL	Extra sectional area, ft^2 (model scale)

Table 1 - Required Input Information for Running HYDRO (Cont)

CARD	FORMAT	COL	NAME	DESCRIPTION
9	F10.5	1-10	SF	Forward station where the draft is taken.
	F10.5	11-20	SA	Aft station where the draft is taken.
	F10.5	21-30	TF	Forward draft, ft. (model scale)
	F10.5	31-40	TA	Aft draft, ft (model scale)
	I5	41-45	IPRINT	If not zero, large output table will be printed.
10	F10.5	21-30	X	Station offset distance from F.P. (positive aft)
	F10.5	31-40	Y	Beam
	F10.5	41-50	Z	height above baseline
10a	The card following the last card 10 must have 99999. or greater starting in column 21.			
11	(ignored if no bow profile is entered)			
	F10.5	21-30	XB	Bow offset distance from FP (positive aft)
	F10.5	31-40	YB	Height above baseline
11a	The card following the last card 11 must have 99999. or greater starting in column 21.			
12	(ignored if no stern profile is entered)			
	F10.5	21-30	XS	Stern offset Distance from FP (positive aft)
	F10.5	31-40	YS	Height above baseline
12a	The card following the last card 12 must have 99999. or greater starting in column 21.			

Table 1 - Required Input Information for Running HYDRO (Cont)

NOTE - Cards 10 and 10a are the input cards for the offsets in the new format. The corresponding cards for the old format are:

CARD	FORMAT	COLS	NAME	DESCRIPTION
10	8F10.5	1-80	X	Station distance from forward perpendicular
10a	I5	1-5	MM	Number of offsets in a given station
10b	8F10.5	1-80	Y	Beam offsets at a given station
10c	8F10.5	1-80	Z	Height offsets at a given station.

The series of cards 10a - c repeat N times.

```
9876
EXAMPLE RUN FOR PROGRAM HYDRO
31.435     4.637     27.358     27.358     1.368
.0833333   .0833333  .0833333   0833333    .0833333
13.673     62.4          1      0
.0         .0        .0         0          1
   25    1    1    3
    3  1.6
16.        .02
17.        .06
18.        .1
0.0        19.0      1.098      1.098      1
                     0.0        0.0        11.4522
                     0.000000   0.095[illegible]36   13.17003
                     0.000000   0.5[illegible]00   15.2[illegible]60
                     8.207413   0.62[illegible]25   1.678300
                     8.207413   0.6[illegible]49   1.908701
                     8.207413   0.724[illegible]31   2.863051
                     8.207413   0.792[illegible]35   3.817402
                     8.207413   0.870451   5.726102
                     8.207413   [illegible]11[illegible]91   7.634803
                     8.207413   0.935[illegible]69   9.543503
                     8.207413   1.020[illegible]93   11.45220
                     8.207413   1.21[illegible]93   13.17003
                     8.207413   1.751[illegible]58   15.2[illegible]60
                     16.41482   0.61[illegible]68   0.000000
                     16.41482   0.9[illegible]74   0.95[illegible]351
                     16.41482   1.204387   1.9087[illegible]
                     16.41482   1.3[illegible]64   2.86[illegible]2
                     16.41482   1.524[illegible]01   [illegible].6132
                     16.41482   1.73761[illegible]   [illegible]3.68193
                     16.41482   1.87[illegible]   13.78322
                     16.41482   [illegible]19   13.88318
                     16.414[illegible]   [illegible].45[illegible]174   13.98324
                     16.[illegible]   8.47[illegible]51   14.09195
                     [illegible]2965   9.532[illegible]49   14.22009
                     [illegible]28.2965   10.6[illegible]08   14.38429
                     328.2965   11.71[illegible]73   14.61164
                     328.2965   12.79443   14.93028
                     99[illegible]99.
                     13.36040              0.000000
                     9.377755              0.954351
                     7.911856              1.908701
                     6.877164              2.863051
                     5.943622              3.817402
                     4.568764              5.726102
                     3.366877              7.634803
                     2.213633              9.543503
                     1.060726              11.45220
                     0.000000              13.17003
                     -1.37241              15.26960
                     -2.71332              17.17830
                     -4.14649              19.08701
                     -5.68381              20.99571
                     -7.32941              22.90441
                     -9.06786              24.81311
                     -10.8930              26.72181
                     -12.8299              28.63051
                     -15.2696              30.73008
                     99999999.
                     246.2224              1.373
                     262.6372              3.241
                     279.0522              5.441
                     295.4668              7.86
                     311.8817              10.488
                     328.2965              13.189
                     99999999.
```

Table 2 - Sample Input for Program HYDRO

TABLE 3

VARIABLE VALUES FOR SAMPLE INPUT

CARD NO.		VARIABLE	VALUES
1		MODEL	9765
2		TITLE	EXAMPLE RUN FOR PROGRAM HYDRO
3		XLAM	31.435
		V	4.637 knots
		XLWL	27.358 ft
		XLPP	27.358 ft
		SS	1.368 ft
4		XX	0.08333 ft/inch
		YY	0.08333
		ZZ	0.08333
		XBS	0.08333
		YBS	0.08333
5		XM	13.679 ft
		WATDEN	62.4 lbs/ft^3
		MET	1
		ISTAT	0
6		XLP	0.0
		ENTA	0.0
		FTE	0.0
		TTE	0.0
		ICALC	1
7		N	25
		NDRAFT	1
		IPROG	1
		IBOW	3
8		NSTAT	3
		EXWET	1.6 ft^2
8a	i	XXL(1)	16.
		EXVOL(1)	0.02 ft^2
	ii	XXL(2)	17
		EXVOL(2)	0.06 ft^2
	iii	XXL(3)	18
		EXVOL(3)	0.10 ft^2

Table 3 - Variable Values for Sample Input (Cont)

VARIABLE VALUES FOR SAMPLE INPUT

CARD NO.	VARIABLE	VALUES
9	SF	0.0
	SA	19.0
	TF	1.1 ft
	TA	1.1 ft
	IPRINT	1
10, 10a	STATION OFFSETS	
11, 11a	BOW OFFSETS	
12, 12a	STERN OFFSETS	

EXAMPLE RUN FOR PROGRAM HYDRO

INPUT DATA

SCALE RATIO	=	31.435
MODEL SPEED	=	4.637
LWL	=	27.358
LBP	=	27.358
STATION SPACING	=	1.368
X AXIS SCALING FACTOR	=	.083
Y AXIS SCALING FACTOR	=	.083
Z AXIS SCALING FACTOR	=	.083
X AXIS SCALING FACTOR FOR BOW AND STERN	=	.083
Y AXIS SCALING FACTOR FOR BOW AND STERN	=	.083
BOW TO MIDSHIPS	=	13.679
WATER DENSITY	=	62.400
MET (OUTPUT UNIT INDEX)	=	1
PARALLEL MIDDLEBODY LENGTH	=	0.000
HALF ANGLE OF ENTRANCE	=	0.000
TAYLOR"S F	=	0.000
TAYLOR"S T	=	0.000
ICALC	=	1
NO. OF STATIONS	=	25
NO. OF DRAFTS	=	1
INPUT STYLE (IPROG)	=	1
IBOW	=	3
ADDED WETTED SURFACE	=	1.600
NSTAT	=	3

ADDED STATION AREA

STATION	AREA
16.00	.0200
17.00	.0600
18.00	.1000

DRAFT INFORMATION

NO.	FWD STATION	FWD DRAFT	AFT STATION	AFT DRAFT
1	0.00	1.10	19.00	1.10

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units

Table 4- Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

STATION 0.00

X = 0.00

HEIGHT ABOVE BASELINE	HALF BREADTH
.954	0.000
1.098	.008
1.272	.045

STATION .50

X = .68

HEIGHT ABOVE BASELINE	HALF BREADTH
.140	.052
.159	.054
.239	.060
.318	.066
.477	.073
.636	.076
.795	.078
.954	.085
1.098	.101
1.272	.146

STATION 1.00

X = 1.37

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.054
.080	.081
.159	.100
.239	.115
.318	.127
.477	.145
.636	.156
.795	.166
.954	.180
1.098	.203
1.272	.253

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

STATION 1.50

X = 2.05

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.070
.080	.123
.159	.158
.239	.183
.318	.204
.477	.236
.636	.257
.795	.274
.954	.294
1.098	.321
1.272	.372

STATION 2.00

X = 2.74

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.085
.034	.132
.080	.176
.159	.228
.198	.248
.239	.267
.318	.298
.446	.335
.477	.342
.636	.373
.732	.389
.795	.398
.954	.425
.967	.427
1.098	.455
1.132	.464
1.253	.502

STATION 2.50

X = 3.42

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.094
.010	.134
.080	.248
.090	.260
.159	.319
.239	.367
.240	.368
.318	.402

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

.452	.448
.477	.456
.636	.500
.668	.507
.795	.536
.863	.552
.954	.573
1.023	.590
1.098	.613
1.272	.677

STATION 3.00

X = 4.10

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.131
.001	.134
.032	.266
.080	.344
.120	.387
.159	.420
.239	.472
.267	.488
.318	.514
.436	.569
.477	.587
.605	.635
.636	.646
.769	.688
.795	.695
.916	.732
.954	.745
1.040	.775
1.098	.796
1.149	.815
1.246	.854

STATION 4.00

X = 5.47

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.005	.279
.024	.402
.075	.528
.153	.645
.252	.750
.368	.842
.494	.920
.623	.987
.754	1.043

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

.795	1.058
.881	1.091
.954	1.114
1.003	1.131
1.098	1.162
1.118	1.168
1.225	1.203
1.272	1.217

STATION 5.00

X = 6.84

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.010	.478
.014	.541
.039	.676
.087	.804
.154	.924
.240	1.033
.340	1.131
.454	1.216
.577	1.288
.707	1.347
.795	1.379
.837	1.396
.954	1.433
1.085	1.476
1.098	1.479
1.202	1.509
1.272	1.527

STATION 6.00

X = 8.21

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.016	.736
.022	.825
.049	.964
.096	1.097
.166	1.220
.256	1.331
.362	1.428
.483	1.510
.612	1.578

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

.746	1.634
.795	1.647
.881	1.680
.954	1.698
1.014	1.718
1.098	1.739
1.143	1.751
1.268	1.780

STATION 7.00

X = 9.58

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.023	1.017
.031	1.126
.066	1.271
.129	1.404
.216	1.523
.324	1.625
.449	1.710
.586	1.778
.731	1.830
.795	1.844
.878	1.869
.954	1.882
1.023	1.899
1.098	1.912
1.164	1.923
1.272	1.936

STATION 8.00

X = 10.94

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.026	1.129
.029	1.271
.030	1.289
.058	1.445

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

.119	1.586
.212	1.707
.333	1.804
.475	1.878
.629	1.932
.790	1.966
.795	1.967
.952	1.987
.954	1.987
1.098	1.997
1.109	1.998
1.260	2.003

STATION 9.00

X = 12.31

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.026	1.129
.030	1.290
.034	1.446
.034	1.459
.065	1.621
.141	1.758
.257	1.865
.404	1.942
.575	1.986
.758	2.003
.795	2.004
.864	2.004
.938	2.004
.954	2.004
1.098	2.004
1.105	2.004
1.259	2.004
1.272	2.004

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

STATION 10.00

X = 13.68

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.026	1.129
.030	1.290
.034	1.459
.035	1.504
.054	1.628
.121	1.773
.228	1.889
.373	1.970
.558	2.003
.606	2.004
.756	2.004
.795	2.004
.938	2.004
.954	2.004
1.098	2.004
1.105	2.004
1.259	2.004
1.272	2.004

STATION 11.00

X = 15.05

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.026	1.129
.030	1.290
.034	1.443
.034	1.459
.061	1.623
.129	1.766
.239	1.881
.384	1.960
.559	2.001
.617	2.004

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

.756	2.004
.795	2.004
.938	2.004
.954	2.004
1.098	2.004
1.105	2.004
1.259	2.004
1.272	2.004

STATION 12.00

X = 16.41

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.026	1.129
.030	1.290
.030	1.302
.046	1.452
.091	1.604
.166	1.740
.271	1.854
.407	1.939
.573	1.988
.757	2.003
.795	2.004
.862	2.004
.938	2.004
.954	2.004
1.098	2.004
1.105	2.004
1.259	2.004
1.272	2.004

STATION 13.00

X = 17.78

HEIGHT ABOVE BASELINE	HALF BREADTH
0.000	.095
.001	.134
.004	.269
.008	.404
.011	.542
.015	.682
.018	.826
.022	.975
.024	1.075
.026	1.128

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

.041	1.284
.074	1.436
.130	1.579
.215	1.705
.326	1.810
.460	1.892
.614	1.947
.779	1.978
.795	1.983
.946	1.994
.954	1.995
1.098	2.000
1.107	2.001
1.259	2.004
1.272	2.004

STATION 14.00

X = 19.15

HEIGHT ABOVE BASELINE	HALF BREADTH
.021	0.000
.030	.133
.039	.265
.047	.398
.056	.532
.065	.669
.074	.808
.084	.951
.099	1.096
.121	1.243
.154	1.390
.208	1.528
.291	1.649
.401	1.749
.532	1.827
.678	1.883
.795	1.912
.831	1.921
.954	1.937
.984	1.947
1.098	1.960
1.133	1.965
1.272	1.974

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

STATION 15.00

X = 20.52

HEIGHT ABOVE BASELINE	HALF BREADTH
.114	0.000
.129	.127
.142	.254
.155	.381
.168	.509
.180	.638
.193	.769
.206	.904
.222	1.041
.243	1.181
.273	1.321
.322	1.454
.398	1.571
.500	1.669
.621	1.747
.754	1.807
.795	1.820
.894	1.852
.954	1.862
1.034	1.886
1.098	1.898
1.171	1.912
1.272	1.926

STATION 16.00

X = 21.89

HEIGHT ABOVE BASELINE	HALF BREADTH
.270	0.000
.283	.119
.296	.238
.308	.357
.321	.476
.335	.596
.347	.719
.360	.845
.373	.974
.392	1.105
.420	1.236
.464	1.362
.531	1.475
.621	1.571
.727	1.652
.795	1.691
.844	1.717
.954	1.759
.968	1.769
1.094	1.811
1.220	1.845

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

1.272	1.855

STATION 17.00

X = 23.25

HEIGHT ABOVE BASELINE	HALF BREADTH
.453	0.000
.465	.110
.477	.219
.488	.328
.500	.438
.512	.549
.525	.662
.536	.777
.549	.896
.565	1.017
.590	1.138
.627	1.256
.682	1.365
.756	1.461
.795	1.502
.846	1.544
.947	1.614
.954	1.615
1.056	1.671
1.098	1.690
1.170	1.718
1.272	1.752

STATION 18.00

X = 24.62

HEIGHT ABOVE BASELINE	HALF BREADTH
.655	0.000
.666	.099
.676	.198
.687	.297
.698	.396
.709	.496
.720	.598
.731	.702
.743	.809
.758	.919
.777	1.030
.795	1.105
.806	1.139
.849	1.244
.906	1.340
.954	1.396
.979	1.425
1.063	1.498
1.098	1.522
1.158	1.558
1.259	1.608

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

1.272	1.613

STATION 19.00

X = 25.99

HEIGHT ABOVE BASELINE	HALF BREADTH
.874	0.000
.884	.088
.893	.175
.901	.263
.911	.351
.920	.440
.930	.530
.940	.622
.950	.717
.954	.750
.962	.814
.978	.914
.998	1.015
1.028	1.113
1.070	1.207
1.098	1.255
1.125	1.293
1.191	1.370
1.270	1.433
1.272	1.437

STATION 20.00

X = 27.36

HEIGHT ABOVE BASELINE	HALF BREADTH
1.099	0.000
1.107	.076
1.116	.152
1.124	.228
1.132	.304
1.140	.381
1.149	.459
1.157	.539
1.165	.621
1.174	.706
1.185	.794
1.199	.885
1.218	.976
1.244	1.066

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

BOW PROFILE

HEIGHT ABOVE BASELINE	LONGITUDINAL DISTANCE
0.000	1.113
.080	.781
.159	.659
.239	.573
.318	.499
.477	.381
.636	.281
.795	.184
.954	.088
1.098	0.000
1.272	-.114
1.432	-.226
1.591	-.346
1.750	-.474
1.909	-.611
2.068	-.756
2.227	-.908
2.386	-1.069
2.561	-1.272

STERN PROFILE

HEIGHT ABOVE BASELINE	LONGITUDINAL DISTANCE
.114	20.519
.270	21.886
.453	23.254
.655	24.622
.874	25.990
1.099	27.358

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

EXAMPLE RUN FOR PROGRAM HYDRO

DRAFTS

MIDSHIPS DRAFT	FWD STATION	FWD DRAFT	AFT STATION	AFT DRAFT
1.10	0.00	1.10	19.00	1.10

VOLUME	=	69.788
DISPLACEMENT	=	4354.798
WATERPLANE AREA	=	82.427
WETTED SURFACE	=	116.299
COMPUTED WATERLINE LENGTH	=	27.352
STATION AT AX	=	10.00

X	BEAM	GIRTH	AREA
0.000	.016	.288	.001
.684	.203	2.024	.144
1.368	.407	2.331	.314
2.052	.642	2.415	.508
2.736	.910	2.544	.735
3.420	1.226	2.730	.992
4.104	1.591	2.975	1.290
5.472	2.325	3.548	1.974
6.840	2.959	4.146	2.641
8.207	3.479	4.685	3.230
9.575	3.825	5.110	3.687
10.943	3.993	5.418	3.939
12.311	4.008	5.616	4.156
13.679	4.008	5.689	4.201
15.047	4.008	5.660	4.185
16.415	4.008	5.567	4.127
17.783	4.000	5.420	4.007
19.151	3.920	5.161	3.658
20.519	3.797	4.803	3.097
21.886	3.624	4.367	2.439
23.254	3.380	3.869	1.764
24.622	3.046	3.284	1.102
25.990	2.512	2.569	.370
27.358	0.000	0.000	0.000

Table 4 - Sample Output for Program HYDRO with Output Tables in English and SI Units (Cont)

```
                                   SHIP AND MODEL DATA
                                      MODEL 9876

EXAMPLE RUN FOR PROGRAM HYDRO
  DESCRIPTION                          S H I P          M O D E L
  -----------                          -------          ---------
                   ENG. METRIC     ENG.   METRIC     ENG.   METRIC
                   -----------     -------------     -------------
WL LENGTH   (LWL) FT      M        860.0   262.1     27.36    8.34    LINEAR RATIO = 31.435
LENGTH BP   (LPP) FT      M        860.0   262.1     27.36    8.34    V SQRT(LWL)  =    .887
BEAM AT AX  (BX)  FT      M        126.0    38.4      4.01    1.22    FROUDE NO.   =    .264
DRAFT AT AX (TX)  FT      M         34.5    10.5      1.10     .33    CIRCLE K     =   2.410
DISPLACEMENT(DIS)TON TONNE      62104SW 63100SW      1.94FW  1.98FW   XFB/LWL      =    .515
                  LBS                             4354.8              XFB/LPP      =    .515
WETTED SURF.(S)SQ FT   M SQ 114922.0 10676.6    116.30   10.80        XFF/LWL      =    .574
DESIGN SPEED(V)   KTS  M/S      26.0    13.4      4.64    2.39        1/2 ENT.ANGLE=  3.3  DEG
                                                                      1/2 ENT.ANGLE=   .058RAD

                              LWL COEFFICIENTS                              LPP COEFFICIENTS
---------------------------------------------------------------------    ----------------
CB  = .580       CPE  = .57       LE/L  =  .50      D-L  =  97.64         CB   =   .580
CP  = .607       CPR  = .64       LP/L  = 0.00      CVOL=   3.41E-3       CP   =   .607
CX  = .954       CVP  = .77       LR/L  =  .50      CWS  =  15.73         L/BX =  6.83
CWP = .752       CVPA = .71       L/BX  = 6.83      CS   =   2.66         D-L  = 97.64
CPF = .57        CVPF = .86       BX/TX = 3.65      FTE  =    .02         CVOL =  3.41E-3
CPA = .64        CWPF = .64                         TTE  =    .68
                 CWPA = .87
                                  ********************
FWD STATIONS
  0.00   .50  1.00  1.50  2.00  2.50  3.00  4.00  5.00  6.00  7.00  8.00  9.00 10.00
A AX
  .000  .034  .075  .121  .175  .236  .307  .470  .629  .769  .878  .952  .989 1.000
B BX
  .004  .051  .102  .160  .227  .306  .397  .580  .738  .868  .954  .996 1.000 1.000
                                  ********************
AFT STATIONS
 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00 20.00
A AX
  .996  .982  .954  .871  .737  .581  .420  .262  .088 0.000
B/BX
 1.000 1.000  .998  .978  .947  .904  .843  .760  .627 0.000


THE SHIP DISPLACEMENT IS CALCULATED FOR SALT WATER AT 59 DEGREES F (15 DEGREES C)
THE MODEL DISPLACEMENT IS CALCULATED FOR FRESH WATER AT 73 DEGREES F (22.8 DEGREES C)
```

Table 4 - Sample Output for Program HYDRO with Output Tables
in English and SI Units (Cont)

```
                                  SHIP AND MODEL DATA
                                     MODEL 9876

EXAMPLE RUN FOR PROGRAM HYDRO
  DESCRIPTION                          S H I P          M O D E L
  -----------                          -------          ---------
                   ENG. METRIC     ENG.    METRIC     ENG.    METRIC
                   -----------     --------------     -------------

WL LENGTH   (LWL) FT     M       860.0    262.1    27.358    8.339   LINEAR RATIO = 31.435
LENGTH BP   (LPP) FT     M       860.0    262.1    27.358    8.339   V/SQRT(LWL)  =    .887
BEAM AT AX  (BX)  FT     M       126.0     38.4     4.008    1.222   FROUDE NO.   =    .264
DRAFT AT AX (TX)  FT     M        34.5     10.5     1.098     .335   CIRCLE K     =   2.410
DISPLACEMENT(DIS)TON TONNE    62104SW  63100SW     1.944FW 1.975FW   XFB/LWL      =    .515
                 LBS                           4354.8                XFB/LPP      =    .515
WETTED SURF.(S)SQ FT  M SQ 114922.0  10676.6   116.299   10.805     XFF/LWL      =    .574
DESIGN SPEED(V)  KTS   M/S     26.0     13.4     4.637    2.385     1/2 ENT.ANGLE=   3.3  DEG
                                                                     1/2 ENT.ANGLE=    .058RAD
                          LWL COEFFICIENTS                             LPP COEFFICIENTS
-------------------------------------------------------------------  ---------------
CB  = .580     CPE  = .575     LE/L  = .500     D-L = 97.640        CB   =    .580
CP  = .607     CPR  = .640     LP/L  =0.000     CVOL=  3.408E-3     CP   =    .607
CX  = .954     CVP  = .771     LR/L  = .500     CWS = 15.725        L/BX =  6.825
CWP = .752     CVPA = .706     L/BX  =6.825     CS  =  2.662        D-L  = 97.640
CPF = .575     CVPF = .860     BX/TX =3.651     FTE =   .017        CVOL =  3.408E-3
CPA = .640     CWPF = .638                      TTE =   .685
               CWPA = .865
                                ITTC COEFFICIENTS
                                -----------------
           CM       =  .954     CIRCLE M = 6.645      CIRCLE B =  .974
           CIRCLE T =  .267     CIRCLE S = 6.861
```

STATION	A/AX	B/BX
0.00	.000	.004
.50	.034	.051
1.00	.075	.102
1.50	.121	.160
2.00	.175	.227
2.50	.236	.306
3.00	.307	.397
4.00	.470	.580
5.00	.629	.738
6.00	.769	.868
7.00	.878	.954
8.00	.952	.996
9.00	.989	1.000
10.00	1.000	1.000
11.00	.996	1.000
12.00	.982	1.000
13.00	.954	.998
14.00	.871	.978
15.00	.737	.947
16.00	.581	.904
17.00	.420	.843
18.00	.262	.760
19.00	.088	.627
20.00	0.000	0.000

THE SHIP DISPLACEMENT IS CALCULATED FOR SALT WATER AT 59 DEGREES F (15 DEGREES C)
THE MODEL DISPLACEMENT IS CALCULATED FOR FRESH WATER AT 73 DEGREES F (22.8 DEGREES C)

Table 5 - Sample Output Tables for Program HYDRO in English Units

SHIP AND MODEL DATA
MODEL 9876

EXAMPLE RUN FOR PROGRAM HYDRO

	SHIP	MODEL
WL LENGTH (LWL) FT	860.0	27.36
LENGTH BP (LPP) FT	860.0	27.36
BEAM AT AX (BX) FT	126.0	4.01
DRAFT AT AX (TX) FT	34.5	1.10
DISPLACEMENT(DIS)TONS	62104. SW	1.94FW
LBS		4354.8
WETTED SURF. (S)SQ FT	114922.	116.30
DESIGN SPEED (V) KTS	26.0	4.64

LINEAR RATIO	=	31.4[illegible]5
V/SQRT(LWL)	=	.[illegible]
CIRCLE K	=	2.4[illegible]
CIRCLE P	=	.8[illegible]9
XFB/LWL	=	.515
XFB/LPP	=	.515
XFF/LWL	=	.574
1/2 ENT.ANGLE	=	3.3 DEG

LWL COEFFICIENTS

CB =	.580	CPE =	.57	LE/L =	.50
CP =	.607	CPR =	.64	LP/L =	0.00
CX =	.954	CVP =	.77	LR/L =	.50
CWP =	.752	CVPA =	.71	L/BX =	6.83
CPF =	.57	CVPF =	.86	BX/TX =	3.65
CPA =	.64	CWPF =	.64	D-L =	97.64
		CWPA =	.87	CWS =	15.73

LPP COEFFICIENTS

CB	=	.580
CP	=	.607
L/BX	=	6.83
D-L	=	97.64
FTE	=	.02
TTE	=	.68

****

FWD STATIONS

0.00	.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
A/AX													
.000	.034	.075	.121	.175	.236	.307	.470	.629	.769	.878	.952	.989	1.000
B/BX													
.004	.051	.102	.160	.227	.306	.397	.580	.738	.868	.954	.996	1.000	1.000

****

AFT STATIONS

11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00
A/AX									
.996	.982	.954	.871	.737	.581	.420	.262	.088	0.000
B/BX									
1.000	1.000	.998	.978	.947	.904	.843	.760	.627	0.000

THE SHIP DISPLACEMENT IS CALCULATED FOR SALT WATER AT 59 DEGREES F (15 DEGREES C)
THE MODEL DISPLACEMENT IS CALCULATED FOR FRESH WATER AT 73 DEGREES F (22.8 DEGREES C)

Table 5 - Sample Output Tables for Program HYDRO in English Units (Continued)

SHIP AND MODEL DATA
MODEL 9876

EXAMPLE RUN FOR PROGRAM HYDRO

	SHIP	MODEL
WL LENGTH (LWL) FT	860.0	27.358
LENGTH BP (LPP) FT	860.0	27.358
BEAM AT AX (BX) FT	126.0	4.008
DRAFT AT AX (TX) FT	34.5	1.098
DISPLACEMENT(DIS) TONS	62104. SW	1.944FW
LBS		4354.8
WETTED SURF. (S)SQ FT	114922.	116.299
DESIGN SPEED (V) KTS	26.0	4.637

LINEAR RATIO	=	31.435
V/SQRT(LWL)	=	.887
CIRCLE K	=	2.410
CIRCLE P	=	.849
XFB LWL	=	.515
XFB LPP	=	.515
XFF LWL	=	.574
1/2 ENT.ANGLE	=	3.3 DEG

LWL COEFFICIENTS

CB =	.580	CPE =	.575	LE/L =	.500
CP =	.607	CPR =	.640	LP/L =	0.000
CX =	.954	CVP =	.771	LR/L =	.500
CWP =	.752	CVPA =	.706	L/BX =	6.825
CPF =	.575	CVPF =	.860	BX/TX =	3.651
CPA =	.640	CWPF =	.638	D-L =	97.64
		CWPA =	.865	CWS =	15.73

LPP COEFFICIENTS

CB =	.580
CP =	.607
L/BX =	6.825
D-I =	97.64
FTE =	.02
TTE =	.68

ITTC COEFFICIENTS

CM =	.954
CIRCLE M =	6.645
CIRCLE B =	.974
CIRCLE T =	.267
CIRCLE S =	6.861

STATION	A/AX	B/BX
0.00	.000	.004
.50	.034	.051
1.00	.075	.102
1.50	.121	.160
2.00	.175	.227
2.50	.236	.306
3.00	.307	.397
4.00	.470	.580
5.00	.629	.738
6.00	.769	.868
7.00	.878	.954
8.00	.952	.996
9.00	.989	1.000
10.00	1.000	1.000
11.00	.996	1.000
12.00	.982	1.000
13.00	.954	.998
14.00	.871	.978
15.00	.737	.947
16.00	.581	.904
17.00	.420	.843
18.00	.262	.760
19.00	.088	.627
20.00	0.000	0.000

THE SHIP DISPLACEMENT IS CALCULATED FOR SALT WATER AT 59 DEGREES F (15 DEGREES C)
THE MODEL DISPLACEMENT IS CALCULATED FOR FRESH WATER AT 73 DEGREES F (22.8 DEGREES C)

Table 6 - Sample Output Tables for Program HYDRO in SI Units

```
                         SHIP AND MODEL DATA
                              MODEL 9876

EXAMPLE RUN FOR PROGRAM HYDRO
                                 SHIP         MODEL
                                 ----         -----
WL LENGTH   (LWL) M             860.0         27.36              LINEAR RATIO = 31.435
LENGTH BP   (LPP) M             860.0         27.36              FROUDE NO.   =    .283
BEAM AT AX   (BX) M             126.0          4.01              CIRCLE K     =   2.587
DRAFT AT AX  (TX) M              34.5          1.10              XFB/LWL      =    .515
DISPLACEMENT(DIS)TONNE 2223882   SW          69.62FW             XFB/LPP      =    .515
WETTED SURF. (S) M SQ   114922.              116.30              XFF/LWL      =    .574
DESIGN SPEED (V) M/S             26.0          4.64              1/2 ENT.ANGLE=   0.000RAD

                       LWL COEFFICIENTS                                 LPP COEFFICIENTS
--------------------------------------------------------------          ----------------
CB  =  .580          CPE  =  .57          LE/L   =   .50                 CB    =    .580
CP  =  .607          CPR  =  .64          LP/L   =  0.00                 CP    =    .607
CX  =  .954          CVP  =  .77          LR/L   =   .50                 L/BX  =   6.83
CWP =  .752          CVPA =  .71          L/BX   =  6.83                 CVOL  =   3.41E-3
CPF =  .57           CVPF =  .86          BX/TX  =  3.65
CPA =  .64           CWPF =  .64          CVOL   =  3.41E-3              FTE   =    .02
                     CWPA =  .87          CS     =  2.66                 TTE   =    .68

                                 ******************
FWD STATIONS
  0.00   .50   1.00   1.50   2.00   2.50   3.00   4.00   5.00   6.00   7.00   8.00   9.00  10.00
A/AX
  .000   .034   .075   .121   .175   .236   .307   .470   .629   .769   .878   .952   .989  1.000
B/BX
  .004   .051   .102   .160   .227   .306   .397   .580   .738   .868   .954   .996  1.000  1.000
                                 ******************
AFT STATIONS
 11.00  12.00  13.00  14.00  15.00  16.00  17.00  18.00  19.00  20.00
A/AX
  .996   .982   .954   .871   .737   .581   .420   .262   .088  0.000
B/BX
 1.000  1.000   .998   .978   .947   .904   .843   .760   .627  0.000

THE SHIP DISPLACEMENT IS CALCULATED FOR SALT WATER AT 59 DEGREES F (15 DEGREES C)
THE MODEL DISPLACEMENT IS CALCULATED FOR FRESH WATER AT 73 DEGREES F (22.8 DEGREES C)
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Table 6 - Sample Output Tables for Program HYDRO
in SI Units (Continued)

SHIP AND MODEL DATA
MODEL 9876

EXAMPLE RUN FOR PROGRAM HYDRO

	SHIP	MODEL
WL LENGTH (LWL) M	860.0	27.358
LENGTH BP (LPP) M	860.0	27.358
BEAM AT AX (BX) M	126.0	4.008
DRAFT AT AX (TX) M	34.5	1.098
DISPLACEMENT(DIS)TONNE	2223882 SW	69.616FW
WETTED SURF. (S) M SQ	114922.	116.299
DESIGN SPEED (V) M/S	26.0	4.637

LINEAR RATIO	= 31.435
FROUDE NO.	= .283
CIRCLE K	= 2.547
XFB/LWL	= .515
XFB/LPP	= .515
XFF/LWL	= .574
1/2 ENT.ANGLE	= 0.000RAD

LWL COEFFICIENTS

CB = .580	CPE = .575	LE/L = .500
CP = .607	CPR = .640	LP/L = 0.000
CX = .954	CVP = .771	LR/L = .500
CWP = .752	CVPA = .706	L/BX = 6.825
CPF = .575	CVPF = .860	BX/TX = 3.651
CPA = .640	CWPF = .638	CVOL = 3.408E-3
	CWPA = .865	CS = 2.662

LPP COEFFICIENTS

CB	= .580
CP	= .607
L/BX	= 6.825
CVOL	= 3.408E-3
FTE	= .017
TTE	= .685

ITTC COEFFICIENTS

CM = .954	CIRCLE M = 6.645	CIRCLE B = .974
CIRCLE T = .267	CIRCLE S = 6.861	

STATION	A/AX	B/BX
0.00	.000	.004
.50	.034	.051
1.00	.075	.102
1.50	.121	.160
2.00	.175	.227
2.50	.236	.306
3.00	.307	.397
4.00	.470	.580
5.00	.629	.738
6.00	.769	.868
7.00	.878	.954
8.00	.952	.996
9.00	.989	1.000
10.00	1.000	1.000
11.00	.996	1.000
12.00	.982	1.000
13.00	.954	.998
14.00	.871	.978
15.00	.737	.947
16.00	.581	.904
17.00	.420	.843
18.00	.262	.760
19.00	.088	.627
20.00	0.000	0.000

THE SHIP DISPLACEMENT IS CALCULATED FOR SALT WATER AT 59 DEGREES F (15 DEGREES C)
THE MODEL DISPLACEMENT IS CALCULATED FOR FRESH WATER AT 73 DEGREES F (22.8 DEGREES C)

APPENDIX A

DETAILED DESCRIPTIONS OF THE SUBROUTINES AND COMMON BLOCKS

PROGRAM HYDRO

<u>Purpose</u>: To perform a series of hydrostatic calculations on a given model,

<u>Calling Sequence</u>

MAIN PROGRAM

<u>Common Blocks</u>

ADVOL, CONST, FANDT, STOW

<u>Subroutines Called</u>

APPEND, FTCALC, GIRTH, INPUT, MAX, OUTPUT, SINTEG, SPLNT2, SPPLY2

SUBROUTINE APPEND

Purpose: To calculate the waterline intersection with the bow or stern profiles.

Calling Sequence

APPEND (X,Y,N,X1, DRAFT, ND, POINT)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
DRAFT	Real	-----	Input	Drafts of Ship
N	Integer	-----	Input	Number of points in the bow or stern profile
ND	Integer	-----	Input	Number of drafts
POINT	Real	(7)	Output	Longitudinal distance to profile waterline intersection
X	Real	-----	Input	Longitudinal profile offset
X1	Real	-----	Output	Longitudinal distance to furthest forward underwater projection (bow only)
Y	Real	-----	Input	Vertical profile offset

Common Blocks

None.

Subprograms Called.

SPLNT2 , SPPLY 2

Detailed Description

This subroutine calculates the intersection of the bow or stern profile with the waterline(s). Also, a check is made to find the furthest forward underwater projection (i.e., a bulbous bow). These values are used as endpoints on the sectional area curves.

SUBROUTINE CUBC02

Purpose: To calculate the coefficients of a parametric spline using endpoint-tangent information from SPLNT2.

Calling Sequence

Call CUBC02 (SEG,CC)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
SEG	Real	(8,1)	Input	Array containing endpoint-tangent form data from SPLNT2
CC	Real	(14)	Output	Polynomial coefficients of the parametric spline

Subroutines called

None

Common Blocks

None

SUBROUTINE FTCALC

Purpose: To calculate Taylors' f and t and the half angle of entrance.

Calling Sequence

FTCALC (PSEG, SEG, AX, N, BOWPT, XM)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
AX	Real	-----	Input	Maximum Sectional area
N	Integer	-----	Input	Number of stations
BOWPT	Real	-----	Input	Intersection of water-line and bow
PSEG	Real	(8,N)	Input	Parametric spline information for the sectional area curve
SEG	Real	(8,N)	Input	Parametric spline information for the waterplane area curve
XM	Real	-----	Input	Distance from FP to midships

Common Blocks

FANDT

Subroutines Called

CUBCO2, SPPLY2

Detailed Description

Subroutine FTCALC calculates Taylors' f and t, and the half angle of entrance if the input variable ICALC is not zero. This subroutine may not give correct answers if the bow has an unusual shape.

SUBROUTINE GIRTH

Purpose: To calculate the wetted surface.

Calling Sequence

GIRTH (SEG, NS, TE, N, SPAN)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
SEG	Real	(8,40)	Input	Array containing the spline information
NS	Integer	------	Input	Array containing the number of segments to integrate for each draft
TE	Real	------	Input	Array containing the t value for the last segment for each draft
N	Integer	------	Input	Number of drafts
SPAN	Integer	------	Output	Array containing the girth values

Common Blocks

None

Subprograms Called

CUBCO2, SIMSON

Detailed Description

Finds the wetted perimeter of each station for multiple drafts. It interpolates points using the parametric spline data, and then calculates the segment lengths by using simpsons rule to solve the integral equations.

SUBROUTINE INPUT

Purpose: To read in the data

Calling sequence

Call INPUT

Common Blocks

ADVOL, CONST, FANDT, STOW

Subroutines Called

None

Detailed description

This subroutine reads in all of the data, and scales the model offsets.

SUBROUTINE MAX

Purpose: To find the station with the maximum sectional area.

Calling Sequence

MAX (SEG, NPT, YVAL, XVAL)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
NPT	Integer	------	Input	Number of points in array
SEG	Real	(8,NPT)	Input	Parametric spline information of the sectional area curve
YVAL	Real	------	Output	Maximum sectional area
XVAL	Real	------	Output	Longitudinal position of the maximum sectional area value

Common Blocks

None

Subroutines called

CUBCO2

SUBROUTINE OUTPUT

Purpose: To write out the results of the hydrostatic analysis on a ship model.

Calling Sequence

Call Output (VOL, S, WP, AX, BX, TX, AM, BM, TM, TMF, TMA, STA, BEAMS, SECAR, XPT, XFB, XFF)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
AM	REAL	---------	Input	Sectional area at midships
AX	REAL	---------	Input	Maximum sectional area
BEAMS	REAL	(40)	Input	Waterline beam offsets
BM	REAL	---------	Input	Beam at midships
BX	REAL	---------	Input	Beam at the station with the maximum sectional area
TM	REAL	---------	Input	Draft at midships
TMF	REAL	---------	Input	Draft at 0.25 LWL
TMA	REAL	---------	Input	Draft at 0.75 LWL
TX	REAL	----------	Input	Draft at the station with the maximum sectional area
VOL	REAL	(3)	Input	VOL (1)-Volume forward of amidships VOL (2)-Volume aft of amidships VOL (3)-Volume forward of the station with the maximum sectional area

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
SECAR	Real	(40)	Input	The station sectional areas
WP	Real	(2)	Input	WP (1)-Waterplane area forward of midships WP (2)-Waterplane area aft of midships
S	Real	--------	Input	Wetted surface
XFB	Real	--------	Input	Distance from the FP to the LCB
XFF	Real	--------	Input	Distance from the FP to the LCF
XPT	Real	--------	Input	Distance from the FP to the station of maximum sectional area
STA	Real	(40)	Input	Stations distance from FP

Common Blocks

ADVOL, CONST, FANDT

Subroutines Called

None

Detailed description

The results of the hydrostatic analysis are printed in English and/or metric units depending on the value of the variable "MET". Both ship and model scale data are presented, and the water densities are assumed to be 62.4 lbs/ft^3 for the model, and 64.17 lbs/ft^3 for the ship.

SUBROUTINE SIMSON

Purpose: To integrate using Simpsons rule.

Calling Sequence

SIMSON (DIST, VEC, N, VAL)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
DIST	Real	---------	Input	Interval distance
VEC	Real	(N)	Input	Array of values to integrate
N	Integer	---------	Input	Number of elements in VEC
VAL	Real	---------	Output	Value of the integral

Subroutines Called

None

Common Blocks

None

SUBROUTINE SINTEG

Purpose: To integrate a parametrically defined curve.

Calling Sequence
SINTEG (SEG, NS, TE, N AREA)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
SEG	Real	(8,1)	Input	Array containing the parametric spline information.
N	Integer	------	Input	Number of integrations to perform
NS	Integer	(N)	Input	Array containing the last segment to integrate to for each integration.
TE	Real	(N)	Input	Array containing the t value for the last segment to integrate to for each integration
AREA	Real	(N)	Output	Array containing the results of the integration

Subroutines Called

CUBCO2

Common Blocks

None

Detailed description

This subroutine evaluates the Integral $\int_0^{y_1} f\,dy$ where $f = f(x(t), y(t))$, a series of parametric splines.

SUBROUTINE SPLNT2

Purpose: To fit cubic parametric splines segments through a set of data points.

Calling Sequences

Call SPLNT (SEGS, P, NP, NDI, ENDI)

VARIABLES	TYPE	DIMENSION	USE	DESCRIPTION
P	Real	(2,NP)	Input	Array of (x,y) points
NP	Integer	-----	Input	Number of points
NDI	Integer	(2)	Input	Indicates whether slope at first or last point is specified NDI (1)>1 slope at first point is specified NDI (2)>1 slope at last point is specified
ENDI	Real	(2,2)	Input	Slope at first or last point (if NDI>1) ENDI (2,1)- DX/DT at first point ENDI (2,1)- DY/DT at first point ENDI (1,2)- DX/DT at last point ENDI (2,2)- DY/DT at last point
SEGS	Real	(8,NP-1)	Output	Array containing the parametric spline information in endpoint tangent form

Common Blocks

None

Subroutines Called

None

Detailed Description

The subroutine returns the spine information in endpoint-tangent form. It can be changed to a polynomial coefficient form by using subroutine CUBCO2.

SUBROUTINE SPPLY2

Purpose: To find the intersection between a curve defined by a parametric spline and y = constant line

Calling Sequence

Call SPPLY2, (Y, SEGS, NSEGS, PT, NINT, TINT, INT)

VARIABLE	TYPE	DIMENSION	USE	DESCRIPTION
Y	Real	-------	Input	Y value intersecting curve
SEGS	Real	(8, NSEGS)	Input	Array containing the parametric spline information
NSEGS	Integer	-------	Input	Number of segments
PT (1)	Real	-------	Output	X coordinate of the intersection
PT (2)	Real	-------	Output	Y coordinate of the intersection
NINT	Integer	-------	Output	Index of segment in which intersection occurs.
TINT	Real	-------	Output	Value of t parameter at the intersection
INT	Integer	-------	Output	Error return = 1 Intersection found = 3 no intersection

Common Blocks

None

Subroutines Called

CUBCO2

Detailed Description

The t value corresponding to a given Y value is found, and is then used to calculate the X value corresponding to the Y value.

COMMON BLOCK ADVOL

FORTRAN SYMBOL	MATH SYMBOL	TYPE	DESCRIPTION
X		Real	Longitudinal distance of the stations from the FP
SS		Real	Station spacing
XM		Real	Distance from FP to midships
EXVOL		Real	Extra volume to be added to certain stations
XXL		Real	Station numbers to add extra volume to
NSTAT		Real	Number of stations to add extra volume to
EXWET		Real	Added wetted surface

COMMON BLOCK CONST

FORTRAN SYMBOL	MATH SYMBOL	TYPE	DESCRIPTION
XLAM	λ	REAL	Ship to model scale ratio
XLPP	Lpp	REAL	Length between perpendiculars
XLWL	L_{WL}	Real	Waterline length
DENMOD	ρg	REAL	Model water density
V		REAL	Model speed, knots
MET		Integer	Printout control for english or metric units
XLP		Real	length of parallel middlebody
N		Integer	Number of stations
MODEL		Character string	Model number
TITLE		Character string	Title for output

COMMON BLOCK FANDT

FORTRAN SYMBOL	MATH SYMBOL	TYPE	DESCRIPTION
ENTA		Real	Half angle of entrance, degrees
FTE		Real	Taylors' f
TTE		Real	Taylors' t

COMMON BLOCK STOW

FORTRAN SYMBOL	MATH SYMBOL	TYPE	DESCRIPTION
Y		Real	Half beam offsets
Z		Real	Waterline offsets corresponding to Y
ICALC		Integer	Control for calculating the Half angle of entrance and Taylors f and t
IBOW		Integer	Control to indicate if bow and/or stern profiles are input
SF		Real	Forward station where draft is taken
SA		Real	Aft station where draft is taken
TF		Real	Forward draft at SF
TA		Real	Aft draft at SA
IPRINT		Integer	Print Control Variable
XB		Real	X axis offsets for the bow profile (longitudinal)
YB		Real	Z axis offsets (vertical) for the bow profile
XS		Real	X axis offsets for the bow profile (longitudinal)
YS		Real	Z axis offsets (vertical) for the bow profile
MM		Integer	Array containing the number of points per station.

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